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IQ interpretation for children with flat and variable test profiles[☆]

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Abstract

Despite suggestions that IQ reflects an underlying ability trait, a direct comparison of typical and atypical populations using commonality analysis has not been undertaken. In this study, commonality analysis was used to examine unique and common factor predictors of Full-Scale IQ (FSIQ) for typical children with variable ($n=707$) and flat profiles ($n=166$) based on significant index score variability. FSIQ was composed of primarily shared variance for the flat profile group, but unique variance for the variable profile group and the Learning-Disabled (LD) and Attention Deficit/Hyperactivity Disorder (ADHD) samples, suggesting that FSIQ does not adequately represent global intellectual functioning for either typical children with significant profile variability or children with disabilities.

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1. Introduction

Since the earliest days of mental testing, views of the structure of intelligence have differed. A general intelligence (*g*) model posits that mental ability can be measured as a unitary construct. This view has long been espoused by those who consider IQ a meaningful measure of overall cognitive ability. Among modern researchers, [Gottfredson \(1997\)](#) contends that *g* is the best predictor of success, not only in school, but also in later job training and overall occupational success. It has also been linked to a variety of real-world outcomes, including educational attainment, income level, and incarceration ([Herrnstein & Murray, 1994](#)). Perhaps the best known of the *g* proponents is [Arthur Jensen \(1998a, 1998b\)](#), whose body of work has explored the links between psychometric *g* and a variety of other measures. While *g* proponents do not deny the existence of other factors, they minimize their importance in explaining cognitive functioning. In contrast, proponents of a multifactor model of intelligence assume that a variety of cognitive abilities exists and that useful intelligence tests must measure a variety of abilities rather than a unitary IQ (e.g., [Guilford, 1967](#); [Horn & Cattell, 1967](#); [Thurstone, 1938](#)). These theorists focus on the variety of cognitive abilities manifested through psychometric testing. [Guilford's \(1967\) Structure of Intellect Model](#) attempted to recognize the diversity of cognitive abilities by breaking cognitive processes down into 120 factors, differing in content, operation, and product. Theorists currently focusing on cognitive processing are elaborating on a model first articulated in [Thurstone's \(1938\) Primary Mental Abilities](#) and refined through the work of [Horn and Cattell \(1967\)](#). While multiple-factor proponents may or may not acknowledge *g* as a measure of global cognitive ability, they emphasize the importance of a variety of abilities in explaining cognitive functioning.

More recently, [McGrew and Flanagan \(1998\)](#) and their colleagues have combined [Carroll's \(1993\)](#) hierarchical concept of intelligence with [Horn and Cattell's \(1967\)](#) multifactorial model to yield what is known as Cattell–Horn–Carroll or CHC theory. While this type of hierarchical model, with *g* at the apex and several broad abilities underneath, is endorsed by many theorists (e.g., [Carroll, 1993](#); [Elliott, 1990](#); [McGrew & Flanagan, 1998](#)), it is not universally accepted ([Neisser et al., 1996](#)). Perhaps one of the most contentious debates in psychology, the battle between proponents of *g* and proponents of multiple cognitive abilities is played out among practitioners as well as theorists.

Clinicians who assess cognitive ability, such as neuropsychologists and school and clinical psychologists, routinely go beyond the Full-Scale IQ (FSIQ) to look for strengths and weaknesses among a client's cognitive skills. For example, in a recent national survey, 89% of school psychologists indicated that they used index scores, subtest profile analysis, or both in interpreting their clients' performance on the Wechsler Intelligence Scale for Children—Third Edition (WISC-III; [Pfeiffer, Reddy, Kletzel, Schmelzer, & Boyer, 2000](#)). Texts for clinical practitioners present methodologies for interpreting variation in test and subtest scores as measures of different underlying cognitive abilities (e.g., [Kamphaus, 2001](#); [Kaufman, 1994](#); [McGrew & Flanagan, 1998](#); [Sattler, 2001](#)).

[Sattler \(2001\)](#) cautions that the FSIQ may misrepresent a child's cognitive functioning level if the Verbal IQ (VIQ) and Performance IQ (PIQ) are significantly different; however, he

indicates that no empirical evidence exists to indicate when the FSIQ should not be reported or used in eligibility decisions. Prifitera, Weiss, and Saklofske (1998) recommend that FSIQ should not be interpreted when differences between VIQ/PIQ or Verbal Comprehension Index (VCI) and Perceptual Organization Index (POI) scores are extreme, which they define as differences found in less than about 10% of the population.

Neuropsychologists have traditionally de-emphasized interpretation of FSIQ in favor of interpreting specific abilities (e.g., Spreen & Strauss, 1998). Recently, Riccio and Hynd (2000) used MRI to validate the neurological basis for differences in VIQ and PIQ on the WISC-III, finding that children with a smaller left planum temporale (a part of the brain associated with language comprehension) showed a significant difference in favor of PIQ. In addition, Riccio and Hynd's analysis of the psychometrically purer VCI and POI scores yielded even stronger differences, with POI exceeding VCI by more than 15 points in children with smaller left planum temporales.

Several researchers have challenged the validity and utility of profile interpretation (Glutting, McDermott, Konold, Snelbaker, & Watkins, 1998; Glutting, Youngstrom, Ward, Ward, & Hale, 1997; McDermott, Fantuzzo, & Glutting, 1990; Watkins, 2000). McDermott et al. (1990) suggest that clinicians "just say no" to profile analysis and that FSIQs be the only scores interpreted from an intellectual assessment. Sounding a more restrained warning, Kamphaus (1998) notes that clinicians often make interpretations based on clinical experience and judgment that contradict available empirical data and he calls for more research to support empirically informed interpretations.

Some researchers have argued that FSIQ is a more useful measure than are index scores in the prediction of academic achievement, and WISC-III hierarchical regression analyses have indicated that index scores contribute little beyond FSIQ in the prediction of achievement (Glutting et al., 1997). Concluding that index scores have limited incremental validity, Glutting et al. (1997) argue that clinicians should interpret FSIQ only, as such interpretation is the simplest and most efficient method of WISC-III analysis.

However, we find the hierarchical regression method of statistical analysis utilized in these studies problematic. The methodology employed by Glutting et al. (1997) required that FSIQ be force-entered first into the regression equations, leaving little variance for the index predictors. As we and our colleagues have argued elsewhere (Hale, Fiorello, Kavanagh, Hoepfner, & Gaither, 2001), the WISC-III FSIQ and index scores are largely composed of the same subtest scores and thus the same variance. Thus, such analyses yield misleading results. Using the same hierarchical regression procedures, but with index (rather than FSIQ) scores entered first, Hale et al. (2001) found that FSIQ contributes little to the prediction of achievement beyond that explained by index scores.

As these analyses demonstrated that hierarchical regression procedures could be misleading, Hale et al. (2001) used regression commonality analysis (see Pedhazur, 1997) to examine the unique and common predictor variance estimates of FSIQ. This analysis allows one to determine what proportion of variance in an outcome score is predicted by the unique contributions of individual variables uncontaminated by multicollinearity, in addition to the contributions of various combinations of the collinear variables. Using a sample of children with Learning Disorders (LD), Hale et al. demonstrated that FSIQ variance was largely made

up of unique, not common or shared, factor variance, thus calling into question the utility of FSIQ as a unitary measure of “ability” or global intellectual functioning for children with LD.

As intelligence subtest scores are more variable for children with LD, attention deficits, or neurological impairment than for the population at large (Hynd, Cohen, Riccio, & Arceneaux, 1998), practitioners must evaluate whether FSIQ represents global intellectual functioning for children with variable profiles. In addition, most children display a significant amount of variability in their intelligence test profiles (Schinka, Vanderploeg, & Curtiss, 1997), so the question of whether practitioners should interpret FSIQ as a measure of global intellectual functioning for typical children with variable profiles becomes an important one.

This study was undertaken to examine the unique and common factor predictors of FSIQ for the typical population. The purpose was to develop an empirically based recommendation for the clinical interpretation of WISC-III scores. It was hypothesized that children in the standardization group who displayed significant index score variability would show a different pattern of common and shared factor variance estimates of FSIQ than children without such variability. Additionally, it was hypothesized that FSIQ would be composed of primarily unique, not shared, factor variance for children with significantly variable index scores, while FSIQs of children with flat profiles would be composed of primarily shared variance. In addition, as a comparison, we examined the unique and common factor predictors of FSIQ for two special clinical groups reported in the manual, the Learning-Disabled (LD) and Attention Deficit/Hyperactivity Disorder (ADHD) groups. It was hypothesized that FSIQ would be composed of primarily unique variance for these groups.

2. Method

The WISC-III–WIAT linking standardization sample data (Psychological Corporation, 1992; Wechsler, 1991), consisting of children who completed both the WISC-III and WIAT, were used in this study. Participants who obtained an FSIQ below 80 or above 120 were excluded to ensure that the sample did not include children diagnosed with mental retardation or giftedness. The final sample ($N=873$) consisted of 430 female and 443 male children, with an average age of 11.5 years (range 6–17 years). The sample was reasonably well matched to the demographic characteristics of the 1988 census for race/ethnicity, geographic region, and parent education level, and was comparable in terms of grade level distribution (see Psychological Corporation, 1992).

In addition, two WISC-III special group samples were used for comparison purposes (Wechsler, 1991). The children with LD ($n=47$) consisted of 39 males and 8 females, primarily of European American race/ethnicity ($n=43$). The children with ADHD ($n=51$) consisted of 48 males and 3 females, also primarily of European American race/ethnicity ($n=50$). Further information about these samples can be found in the WISC-III and WIAT test manuals (Psychological Corporation, 1992; Wechsler, 1991).

The standardization sample was divided into two groups, the variable profile ($n=707$) group and the flat profile ($n=166$) group, based on the degree of index score variability.

Children included in the variable profile group had one or more WISC-III index score (VCI, POI, Freedom from Distractibility Index [FDI], and Processing Speed Index [PSI]) differences that was statistically significant ($\alpha=.05$) as specified in the WISC-III manual (Wechsler, 1991, p. 261).

Using standard commonality analysis procedures (Pedhazur, 1997), unique and shared index score variance estimates of FSIQ were calculated separately for each group. Unique and shared index score variance estimates for the flat profile and variable profile groups were then compared. In addition, a comparison was made between the variable profile group and the LD and ADHD samples.

3. Results

Standard commonality analysis notation is used in the results. Unique factors are designated by U, with a subscript indicating the WISC-III index score that makes up the factor. Common factors are designated by C, with the subscripts indicating the WISC-III index scores that contribute to the factor. Index score abbreviations are as follows: VCI, POI, FDI, and PSI.

3.1. Flat profile and variable profile group comparison

As noted in Table 1, the two groups were comparable in terms of gender distribution, age distribution, and racial/ethnic makeup. In addition, an ANOVA comparison of the variable profile (mean = 100.24, S.D. = 10.33) and flat profile (mean = 100.21, S.D. = 10.78) group FSIQ means revealed no significant difference ($F=0.001$, $P=.970$).

The commonality results for the flat and variable profile groups are reported in Tables 2 and 3, respectively. For the flat profile group, a large portion of FSIQ variance could be

Table 1
Comparison of the variable profile and flat profile groups

	Variable profile		Flat profile	
	<i>n</i>	%	<i>n</i>	%
Total (<i>N</i> = 873)	707	81	166	19
Gender				
Male	360	51	83	50
Female	347	49	83	50
Race/ethnicity				
European American	556	79	128	77
African American	75	11	19	11
Latino	65	9	17	10
Other	11	2	2	1
Age (months)				
Mean	137.99		139.51	
S.D.	37.41		38.63	

Table 2
Commonality analysis for FSIQ, flat profile standardization group

	Variance explained			
	VC	PO	FD	PS
U _{VC}	.04526			
U _{PO}		.03654		
U _{FD}			.00373	
U _{PS}				.00249
C _{VCPO}	.04204	.04204		
C _{VCFD}	.02394		.02394	
C _{VCPS}	.01007			.01007
C _{POPS}		.01239		.01239
C _{VCPOFD}	.06851	.06851	.06851	
C _{VCPOPS}	.05345	.05345		.05345
C _{VCFDPS}	.02467		.02467	.02467
C _{POFDPS}		.01245	.01245	.01245
C _{VCPOFDPS} (g)	.63609	.63609	.63609	.63609
Unique	.04526	.03654	.00373	.00249
Common	.85877	.83293	.77562	.75108
Total	.90403	.86947	.77935	.75357

Commonalities <.01 not displayed.

accounted for by shared (89%) rather than unique (9%) factor predictors, suggesting that FSIQ is interpretable as a global measure of intellectual functioning for these children. A comparison of unique and common variance estimates for the flat profile group revealed that the most important commonality in predicting FSIQ was C_{VCPOFDPS} (accounting for 64% of

Table 3
Commonality analysis for FSIQ, variable profile standardization group

	Variance explained			
	VC	PO	FD	PS
U _{VC}	.30637			
U _{PO}		.26518		
U _{FD}			.01026	
U _{PS}				.02905
C _{VCPO}	.14350	.14350		
C _{VCFD}	.09823		.09823	
C _{POPS}		.02301		.02301
C _{FDPS}				
C _{VCPOFD}	.05245	.05245	.05245	
C _{VCFDPS}	.01690		.01690	.01690
C _{VCPOFDPS} (g)	.01821	.01821	.01821	.01821
Unique	.30637	.26518	.01026	.02905
Common	.32345	.24740	.20356	.06668
Total	.62982	.51258	.21382	.09573

Commonalities <.01 not displayed.

the variance), with most of the additional variance accounted for by other common factors involving VCI and POI.

In contrast, for the variable profile group, a large portion of FSIQ variance could be accounted for by unique (61%) rather than shared (36%) Index score predictors, suggesting that FSIQ may not adequately represent true “ability” or “potential” for this group. A comparison of unique and common variance estimates for the variable profile group revealed a very different pattern for predictors. Two unique factors, U_{VC} (31%) and U_{PO} (27%), accounted for the majority of FSIQ variance, while several commonalities also accounted for notable amounts of variance, including C_{VCPO} (14%), C_{VCFD} (10%), and C_{VCPOFD} (5%). $C_{VCPOFDPS}$, the commonality consisting of all four index scores, accounted for only 2% of the variance. Overall, the variable profile group presented with a more factorially complex FSIQ, indicating that interpretation of FSIQ as a global measure can be particularly misleading with this group, which constituted a substantial majority of the standardization sample.

3.2. Variable profile and clinical groups comparison

A comparison of unique and common variance estimates for the LD group revealed that 58% of the variance in FSIQ was due to unique contributions of the index scores (see Table 4). Two unique factors, U_{VC} (31%) and U_{PO} (23%), accounted for the majority of FSIQ variance. Several commonalities also accounted for notable amounts of variance, including C_{VCFD} (10%), C_{VCPOFD} (9%), C_{POPS} (7%), C_{POFDPS} (6%), and C_{POFD} (5%). However, $C_{VCPOFDPS}$, the common factor consisting of all four index scores, accounted for only 3%

Table 4
Commonality analysis for FSIQ, LD special validity study group

	Proportion of variance explained			
	VC	PO	FD	PS
U_{VC}	.30746			
U_{PO}		.22513		
U_{FD}			.01539	
U_{PS}				.03448
C_{VCPO}	.02264	.02264		
C_{VCFD}	.09859		.09859	
C_{POFD}		.04929	.04929	
C_{POPS}		.07118		.07118
C_{FDPS}			.01210	.01210
C_{VCPOFD}	.08972	.08972	.08972	
C_{POFDPS}		.05754	.05754	.05754
$C_{VCPOFDPS}$ (g)	.02726	.02726	.02726	.02726
Unique	.30746	.22513	.01539	.03448
Common	.20700	.30022	.34102	.13687
Total	.51446	.52535	.35641	.17135

Commonalities <.01 not displayed.

Table 5
Commonality analysis for FSIQ, ADHD special validity study group

	Proportion of variance explained			
	VC	PO	FD	PS
U _{VC}	.23843			
U _{PO}		.18007		
U _{FD}			.01852	
U _{PS}				.03684
C _{VCPO}	.18811	.18811		
C _{VCFD}	.05467		.05467	
C _{POFD}		.03580	.03580	
C _{POPS}		.04547		.04547
C _{VCPOFD}	.13315	.13315	.13315	
C _{VCPOPS}	.01460	.01460		.01460
C _{POFDPS}		.01100	.01100	.01100
C _{VCPOFDPS (g)}	.01971	.01971	.01971	.01971
Unique	.23843	.18007	.01852	.03684
Common	.40177	.44784	.25701	.08455
Total	.64020	.62791	.27553	.12139

Commonalities <.01 not displayed.

of the FSIQ variance. The factorial complexity of the LD group’s FSIQ data suggests that interpretation of FSIQ as a global measure may be inadvisable for this group.

A comparison of unique and common variance estimates for the ADHD group revealed that 47% of the variance in FSIQ was due to unique contributions of the Index scores (see Table 5). The unique contributions of U_{VC} (24%) and U_{PO} (18%), together with the

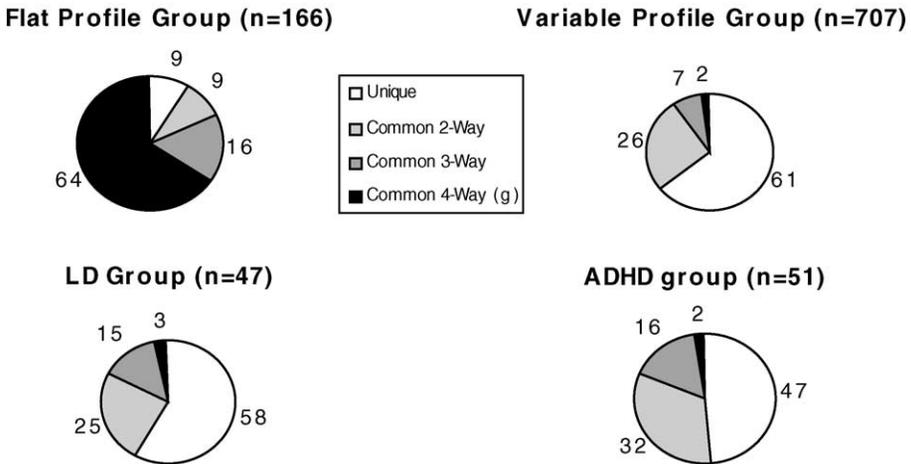


Fig. 1. Comparison of sources of variance in FSIQ.

commonality C_{VCPO} (19%), accounted for the majority of FSIQ variance. The U_{PS} accounted for 4% of FSIQ variance and C_{VCPOFD} (13%) and C_{VCFD} (5%) also accounted for notable amounts of variance. $C_{VCPOFDPS}$, the common factor consisting of all four index scores, accounted for only 2% of the FSIQ variance. Since the ADHD group, like the LD group, presented with a factorially complex FSIQ, interpretation of FSIQ as a global measure could be problematic for this group.

Although there are differences for the two clinical groups and the variable profile group, the overall pattern of findings is similar (see Fig. 1). For all three groups, the $C_{VCPOFDPS}$ factor containing all four index scores explains little of the FSIQ variance, with percentages ranging from 2% to 3%. In addition, all three groups show a large proportion of unique index score contributions to FSIQ, ranging from 47% to 61% of the variance. In contrast, the flat profile group shows the reverse pattern, with $C_{VCPOFDPS}$ explaining 64% of the variance in FSIQ and unique factors contributing only 9%.

4. Discussion

Clinicians have often argued that FSIQ may misrepresent an individual's level of cognitive functioning when differences between component scores are extreme (Kamphaus, 2001; Kaufman, 1994; Prifitera et al., 1998). However, many researchers have challenged profile interpretation and called for interpretation only at the FSIQ level (Glutting et al., 1997, 1988; McDermott et al., 1990; Watkins, 2000). The results of this study support clinicians who examine an individual's pattern of index scores to ensure that FSIQ accurately reflects the examinee's level of general intellectual functioning. For the children with flat profiles in this study, the FSIQ appears to be a global measure of intellectual functioning. However, for children with variable profiles (over 80% of the standardization sample), FSIQ is composed of more unique than shared factor variance. This suggests that for about four-fifths of the typical population, FSIQ may not adequately represent global intellectual functioning. The findings described above suggest that practitioners would do well to de-emphasize FSIQ as a measure of ability and place greater emphasis on index scores, especially when significant index score differences are evident.

In addition to index score interpretation, exploration of common skills across factors may have utility. Using the Wechsler-defined index scores in this study revealed complex interactions that may be elucidated in future analyses. CHC theory provides a model that may more clearly differentiate the cognitive skills underlying WISC-III performance (Flanagan, McGrew, & Ortiz, 2000). Hale et al. (2001) found that converting subtest scores into CHC-based ability scores produced fewer negative commonalities than the index scores in predicting academic achievement and therefore yielded more clearly interpretable results. In addition, Flanagan (2000) found that supplementing Wechsler scores using a CHC-based cross-battery approach increased the amount of variance in reading achievement that could be explained. McGrew, Flanagan, Keith, and Vanderwood (1997) and McGrew and Knopik (1993) have identified the contributions of specific cognitive abilities beyond g in reading, writing, and mathematics achievement. In addition, Woodcock (1993) recommends an

analysis of the information processing demands of intelligence test tasks in order to improve interpretation.

While these results present compelling evidence against uniform interpretation of global FSIQ, they also suggest that we must rethink our conception of intelligence test results in relation to intelligence. If FSIQ is not interpretable as a unitary measure for four-fifths of typical children, in what sense can it be called a measure of general intelligence at all? If FSIQ can only be meaningfully interpreted in those children who do not display significant cognitive variability, then it is simply an ability summary and not necessarily an accurate reflection of an underlying construct of intelligence. By reporting FSIQ regardless of subtest or factor variability, we may be contributing to the reification of a concept that has outlived its usefulness.

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